Many agriculture-associated diseases are characterized by complexity, uncertainty and high potential impact. They call for both analytic thinking, to break problems into manageable components that can be tackled over time, and holistic thinking, to recognize patterns and wider implications as well as potential benefits.

The analytic approach is illustrated in the new decision-support tool developed to address Rift Valley fever in Kenya. In savannah areas of East Africa, climate events trigger a cascade of changes in environment and vectors, causing outbreaks of Rift Valley fever among livestock and (ultimately) humans. Improving information on step-wise events can lead to better decisions about whether, when, where and how to institute control (Anon 2010).

An example of holistic thinking is pattern recognition applied to disease dynamics, recognizing that emerging diseases have multiple drivers. A synoptic view of apparently unrelated health threats—the unexpected establishment of chikungunya fever in northern Italy, the sudden appearance of West Nile virus in North America, the increasing frequency of Rift Valley fever epidemics in the Arabian Peninsula, and the emergence of bluetongue virus in northern Europe—strengthens the suspicion that a warming climate is driving disease expansion generally.

Complex problems often benefit from a synergy of various areas of expertise and approaches. The foresight groups successfully bring together experts in health, environment, agriculture and social development to look at emerging issues (see, for example http://www.bis.gov.uk/foresight). Complex problems also require a longer term view, informed by the understanding that short-term solutions can have unintended effects that lead to long-term problems—as in the case of agricultural intensification fostering health threats. Not every problem requires this broad-spectrum approach, so a first task is to identify specific problems that call for integrative solutions.

New institutions

New, integrative ways of working on complex problems, such as One Health and EcoHealth, require new institutional arrangements. The agriculture, environment and health sectors are not designed to promote integrated, multi-disciplinary approaches to complex, cross-sectoral problems. But many exciting initiatives provide examples of successful institutional collaboration (VSF 2010). For short-term work, joint task forces may be adequate, as in preventing an avian influenza outbreak. For longer-term planning and assessment, stronger cross-sectoral mechanisms may be required, such as joint animal and human health units, integrated knowledge management and information sharing and integrated training programs. Institutional arrangements must carefully consider incentives for changing behaviour, tailored to local contexts, needs and cultures.

Conclusions

Agriculture and health are intimately linked. Many diseases have agricultural roots—food-borne diseases, water-associated diseases, many zoonoses, most emerging infectious diseases, and occupational diseases associated with agrifood chains. These diseases create an especially heavy burden for poor countries, with far-reaching impacts. This brief views agriculture-associated disease as the dimension of public health shaped by the interaction between humans, animals and agroecoystems. This conceptual approach presents new opportunities for shaping agriculture to improve health outcomes, in both the short and long terms.

Understanding the multiple burdens of disease is a first step in its rational management. As agriculture-associated diseases occur at the interface of human health, animal health, agriculture and ecosystems, addressing them often requires systems-based thinking and multi-disciplinary approaches. These approaches, in turn, require new ways of working and institutional arrangements. Several promising initiatives demonstrate convincing benefits of new ways of working across disciplines, despite the considerable barriers to cooperation.

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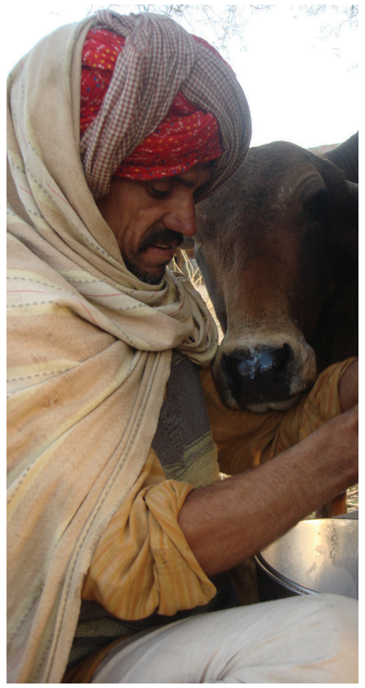

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Agriculture-associated diseases: Adapting agriculture to improve human health

John McDermott and Delia Grace

Agriculture is critical for human welfare, providing food, employment, income and assets. In the past, agricultural research and development largely focused on improving the production, productivity and profitability of agricultural enterprises. The nutritional and other benefits of agriculture were not always optimized, while the negative impacts on health, well-being and the environment were often ignored. This was especially problematic for livestock systems, with especially complex negative and positive impacts on human health and well-being.

An important negative effect of agricultural intensification is disease. Highly pathogenic avian influenza (HPAI) is a notorious example of a disease that was fostered by intensified agricultural production and spread through lengthened poultry value chains and the global movement of people and animals. Large-scale irrigation projects, designed to increase agriculture productivity, have created ecosystems conducive to schistosomiasis and Rift Valley fever.

The responses to disease threats are often compartmentalized. Instead of analysing the tradeoffs between agricultural benefits and risks, the agriculture sector focuses on productivity, while the health sector focuses on managing disease.
A careful look at the epidemiology of diseases associated with agriculture, and past experience of control efforts, shows that successful management must be systems-based rather than sectorally designed.

What are agriculture-associated diseases?

Any disease related to agrifood value chains can be considered agriculture-associated. Such diseases may be associated with agriculture inputs, primary agricultural production, post-harvest processing and handling along marketing chains, or even final preparation by the consumer. The category also includes diseases influenced by ecosystem change for food production (such as large dams) and those associated with incursion of agro-ecosystems into natural ecosystems[1] (such as harvesting wildlife).

The link between agriculture and disease has long been established. This brief examines the range of agriculture-associated diseases to discover commonalities that can be leveraged to achieve better health outcomes. To frame the discussion, we present a typology of four categories of these diseases (Box 1) based on causation and transmission pathways, ranking them by overall impact on human health as measured in DALYs.[2] As with any typology of disease, there are overlaps and ambiguities; the categories are not intended to be absolute but rather to have pragmatic relevance for policy and practice.

1. Natural ecosystems are self-regulating systems without much direct human interference or manipulation.

2. The DALY (disability-adjusted life year) is a measure of healthy years of life lost due to premature death and disability (WHO 2008).

Box 1: Agriculture-associated diseases[3]

At least 61% of all human pathogens are zoonotic (transmissible between animals and people), and zoonoses make up 75% of emerging infectious diseases. A new disease emerges every four months; many are trivial, but HIV, SARS, and avian influenza illustrate the huge potential impacts. Zoonoses and zoonotic diseases recently emerged from animals are responsible for 7% of the total disease burden in least-developed countries.

Water-associated disease
These include the diseases spread by contaminated irrigation water, such as cholera, cryptosporidiosis and chemical intoxication, as well as diseases which breed in irrigation and water storage systems, such as schistosomiasis and malaria (malaria alone kills 1.1 million people annually). For most diseases, water is only one contributing factor. Around 6% of the disease burden in least-developed countries is attributed to water-associated disease.

Food-associated disease
Diarrhoea is one of the top three infectious diseases in most poor countries, killing an estimated 1.4 million children each year. Between 33% and 90% of diarrhoea is attributed to food, and animal-source food is the most risky. More than 90% of food sickness is caused by biological pathogens. Toxins and chemical hazards associated with food are also important health threats, and in many cases can be prevented only by farm-level intervention. Food-associated disease is responsible for 5% of the disease burden in the least-developed countries.

Occupational disease and drug resistance
People working in agrifood systems are directly exposed to a range of biological, chemical and physical hazards. The use of antibiotics in farm animals is known to contribute to the crisis of drug-resistant bacteria in human medicine, although there is debate about its importance and the best way of tackling it. The contribution to disease burden of this category has not been comprehensively assessed; it appears to be an order of magnitude less than the other disease categories.

Why do agriculture-associated diseases matter—and to whom?

As well as sickening and killing billions of people each year, these diseases damage economies, societies and environments. While there is no metric that captures the full cost of disease, assessments of specific disease outbreaks suggest the scale of potential impacts. For example, the SARS epidemic cost USD50–100 billion; the potential costs of an avian influenza pandemic are estimated at USD3 trillion (World Bank 2010). These findings have stimulated rich and middle-income countries to invest heavily in a global program of pandemic prevention and risk reduction.

Most of the absolute burden falls on poor countries. Among low-income countries, diseases directly associated with agriculture (zoonoses of domestic animals and food-borne disease) make up at least 16% of all infectious disease and 6% of the total burden (for comparison, in high-income countries they make up just 4% of the infectious disease burden and only 0.1% of the total disease burden.) The direct economic, social and environmental costs of these diseases are probably proportionate to their adverse health impacts: for example, fungal toxins (mycotoxins) in food lead to trade losses of up to USD1.2 billion a year. Indirect costs of disease are also important. Impaired human health lowers both labour productivity and human capital accumulation (as through schooling and training), worsening livelihood outcomes in both the short and long runs. Malnutrition itself not only is responsible for 3% of the disease burden in low-income countries (WHO 2008), but also enhances vulnerability to disease and is in turn exacerbated by disease symptoms—leading (for example) to a 30-fold increase in the risk for death from diarrhoea (Flint et al. 2005).

Diseases are influenced by socio-economics, environments and policies. There are two broad scenarios that characterize poor countries. At one extreme are neglected areas that lack even the most basic services; in these 'cold spots,' diseases persist that are controlled elsewhere, with strong links to poverty, malnutrition and powerlessness. At the other extreme are areas of rapid intensification, where new and often unexpected disease threats emerge in response to rapidly changing practices and interactions between people, animals and ecosystems. These areas are hot spots for the emergence of new diseases (of which 75% are zoonotic). They also are more vulnerable to food-borne disease, as agricultural supply chains diversify and outpace workable regulatory mechanisms.

Metrics, partnerships and systems-approaches to solve complex problems

Improved metrics

What cannot be measured cannot be effectively and efficiently managed. Addressing agriculture-associated disease requires assessing and prioritizing its impacts, by measuring not only the multiple burdens of disease but also the multiple costs and benefits of potential interventions—across health, agriculture and other sectors. For assessing the human health burden, DALY is the standard metric. There are established methodologies, such as cost analysis and computable general equilibrium models, to measure the cost of illness to households and to the public health sector, as well as the economic costs of livestock disease to agriculture, food industry and other sectors such as tourism. Costs in terms of non-marketed goods and services (such as loss of ecosystem services) can be estimated through willingness to pay and other indirect methods (sporadic and potential diseases are better assessed through decision analysis).

But these assessment tools and results have rarely been integrated to yield a comprehensive assessment of the health, economic and environmental costs of a particular disease. When they are brought together, surprising insights can emerge regarding the true impacts of disease and who bears them, with implications for appropriate policy responses. An example comes from Mongolia, where brucellosis control was shown to be cost-effective from an integrated perspective (Box 2).

3. This table was developed for the Consultative Group on International Agricultural Research (IFPRI and ILRI 2010a). The disease burden estimates listed are cited in Box 1, p 44, of this document, available at http://crp4.cgxchange.org/.

Box 2. Brucellosis control in Mongolia

In Mongolia, a cost–benefit analysis of brucellosis control, examining both medical and veterinary impacts, found that the public health sector reaps only about 10% of the benefits (Roth et al. 2003). Brucellosis control would thus appear less attractive than other disease control expenditure options, in an analysis based solely on DALYs averted. But when the benefits for the livestock sector were included, and the costs shared proportionally by the public health and agricultural sectors, the control of brucellosis actually offered a net gain for both sectors.

Improved metrics for estimating the full costs of disease would open new approaches for the control of agriculture-associated diseases in developing countries. But even with better assessment tools, there remains the challenge of using the results to inform policy decisions. Decision-makers require more than metrics: they need clear evidence on control options and the expected health and economic returns, and they need to consider the socio-political factors that affect the feasibility, sustainability and acceptability of implementation. In the case of brucellosis, these assessments were relatively straightforward. For other agriculture-associated diseases, however, there are high levels of uncertainty regarding epidemiology, impacts and control options (this is true especially for emerging diseases and diseases sensitive to new drivers, such as climate change and evolving agro-ecosystems and food chains). Other diseases have persisted despite medical interventions—especially the neglected tropical zoonoses—indicating a need to tackle the underlying determinants of disease, such as poverty, inequity, lack of information and powerlessness.

Stronger partnerships

Compiling convincing evidence is only the first step in shaping policy. Strong partnerships and high trust will be needed between researchers, stakeholders and policymakers. Policy discussions must go beyond specific control measures to examine the incentives that underpin behaviour and behavioural change.

Systems approaches

The complexities of agriculture-associated diseases call for more integrated and comprehensive approaches to analyse and address them, as envisioned in One Health and EcoHealth perspectives (Box 3). These integrated approaches offer a broad framework for understanding and addressing complex disease: they bring together key elements of human, animal and ecosystem health; and they explicitly address the social, economic and political determinants of health. Both of these global approaches recognize agriculture- and ecosystem-based interventions as a key component of multi-disciplinary approaches for managing diseases. For example, food-borne disease requires management throughout the field-to-fork risk pathway. Zoonoses in particular cannot be controlled, in most cases, while disease remains in the animal reservoir. Similarly, agriculture practices that create health risks require farm-level intervention.

Box 3. One Health and EcoHealth

One Health focuses on the 'integration of human medicine, veterinary medicine and environmental science.' The One Health approach has been defined as the collaborative effort of multiple disciplines to attain optimal health for people, animals and our environment.

EcoHealth, with origins in ecosystem health, has been defined as systemic, participatory approaches to understanding and promoting health and wellbeing, in the context of social and ecological interactions (Waltner-Toews 2009).

The two approaches have much in common and are increasingly aligned; both emphasize multi-disciplinarity and the importance of agriculture and ecosystem-based interventions.

Systemic One Health and EcoHealth approaches require development and testing of methods, tools and approaches to better support management of the diseases associated with agriculture. The potential impacts justify the substantial investment required. An ex ante assessment in Ghana evaluated an integrated package of risk-based measures relating to the use of wastewater for irrigation; it was judged capable of averting up to 90% of an estimated 12,000 DALYs, at an overall cost of less than USD100 per averted DALY (IFPRI and ILRI 2010).

Policy implications

Better information

As a basis for framing sound policies, information is needed on the multiple (that is, cross-sectoral) burdens of disease and the multiple costs and benefits of control, as well as the sustainability, feasibility and acceptability of control options. An example of cross-disciplinary research that effectively influenced policy is the case of smallholder dairy in Kenya. In the light of research by ILRI and partners, assessing both public health risks and poverty impacts of regulation, the health regulations requiring pasteurization of milk were reversed; the economic benefits of the change were later estimated at USD26 million per year. This positive change required new collaboration between research, government and non-governmental organizations and the private sector, as well as new ways of working (see IFPRI and ILRI, 2010, Appendix 4, p 129).